ABSTRACT

A naturalness bias has been defined as ‘a preference for things perceived as natural’. This paper makes a first attempt at answering the question whether a naturalness bias exist in the context of lighting, and whether people’s sense of personal connection to nature and their beliefs towards different types of lighting affect its occurrence. This exploratory paper uses four studies to evaluate the effectiveness of two paradigms of measuring a naturalness bias in the context of lighting. Results indicate that the two presented paradigms did not reliably measure a naturalness bias in the context of lighting. People’s connectedness to nature and beliefs towards different light kinds were reliably and validly measured, providing future research with a good frame of reference for evaluating the effectiveness of other paradigms of measuring a naturalness bias in the context of lighting.

Keywords

Lighting, naturalness bias, natural light, beliefs, connectedness to nature, artificial light.
INTRODUCTION

Since the dawn of civilization it has been clear that sunlight is important to human beings. Daylight plays an important role in our bodily functions and affects both our psychology and physiology. It affects us through dictating our diurnal rhythm, also referred to as our internal clock. This rhythm basically dictates when our body expects to wake up and when it expects to sleep. Another example of a physiological response to daylight is an increase in serotonin levels. Serotonin is a hormone which plays a big role in determining our mood, triggering an increasingly positive and elated mood with rising levels (Aan het Rot, Moskowitz, & Young, 2008).

Today we live in a society that has seen a trend of urbanization continuing for several centuries, increasing the number of people that live in urban areas. In cities, buildings occlude part of the sunlight and people tend to spend more time inside buildings, which are for a large part illuminated by artificial lighting. Both natural light and artificial light play an important role in our life.

Research has shown that people have variety of beliefs about natural and artificial light, such as the effects different kind of light can have on health, mood, social interaction and work efficiency (Veitch & Gifford, 1996). Research has shown that people’s reaction to light is highly influenced by their beliefs about it. For instance, people who believe that light from fluorescent tubes causes health problems or headaches will evaluate it less positively. Similarly, people who believe that fluorescent tubes are energy efficient and have no negative effects evaluate them more positively.

Researchers have described an effect called a ‘naturalness bias’, which has been shown to exist in the contexts of food packaging, foodstuffs and medicine. The naturalness bias can be described as a preference for things which are perceived as being ‘natural’. Scholten and Midden (1997) have shown that people’s attitudes towards food packaging could be better predicted from how ‘natural’ the packaging was perceived, than from how friendly it actually was for the environment. This sparked the idea that a similar dynamic may be influencing people’s attitudes towards daylight and artificial light, meaning that perceptions of how ‘natural’ light is could influence people’s attitudes towards that light.

In two papers by Rozin (2005, 2006) it was found that the process artifacts went through was more important to perceptions of their ‘naturalness’ than their actual physical properties. Rozin (2006) found that two chemically identical substances could receive different ‘naturalness’ ratings when one was created chemically and the other was extracted from a plant. Current research considers whether a similar dynamic could be affecting our perceptions of the ‘naturalness’ of daylight. This would for instance mean that people could rate artificial light which perfectly mimics the physical properties of sunlight as less natural than actual sunlight.
If a naturalness bias indeed exists in the context of lighting, this sparks the questions why it occurs. Literature offers several leads to different factors which can be expected to affect the occurrence of a naturalness bias in the context of lighting.

Veitch and Gifford (1996) explored people’s beliefs about lighting by looking at people’s beliefs about the effects of light on health, performance, mood, and social behavior. One of the conclusions from their study was that people generally believe that fluorescent light has more negative effects on health than other types of light, even though empirical research has not demonstrated such an effect. Another conclusion was that daylight is more suitable for working environments than artificial light. If a naturalness bias exists in the context of lighting, beliefs such as the ones reported by Veitch and Gifford (1996) can be expected to cause or affect the occurrence of this bias. In a paper by Brügger, Kaiser and Roczen (accepted for publishing) researchers devised a reliable method of measuring people’s sense of personal connection to nature by evaluating reports of past bonding activities with nature, and responses to evaluative statements reflecting on participants’ appreciation of nature. People’s degree of ‘connectedness with nature’ can be expected to affect their disposition towards both daylight and artificial light, possibly affecting the occurrence of a naturalness bias in the context of lighting.

In a study by Rozin (2004), researchers looked at the dynamics behind people’s preference for natural food and medicine. It was found that people’s preference for things which were perceived as being ‘natural’ had two bases. Firstly, people perceived ‘natural’ entities as having superior advantages such as being more attractive, appealing, healthy and better for the environment. We will refer to this as the ‘instrumental’ basis for the naturalness bias. Secondly, people perceived ‘natural’ entities as being inherently better and ‘morally right’. We will refer to this as the ‘ideational’ basis for the naturalness bias. These findings give rise to the idea that people’s preference for natural light could either originate from the idea that its physical properties make it more beneficial to for instance people’s health, or from the idea that daylight is more moral or ‘right’ to use because of its implicit and moral superiority, rather than functional superiority.

To the best of our knowledge, this is the first research tackling the question whether a naturalness bias exists in the context of lighting. This paper is thus the first attempt at exploring a new field of lighting research.
**RESEARCH GOALS**

The first goal of this paper is to discover whether or not naturalness bias exists in the context of lighting. In order to answer this question, it is necessary to find a paradigm which is suitable to reliably elicit this bias. This paper aims to evaluate different methods of eliciting a naturalness bias in the context of lighting in order to find a paradigm that works. The second goal of this study is to explore factors which might cause or affect the occurrence of this bias, in order to evaluate why it occurs. To achieve this second goal, we look at different possible bases for the naturalness bias. The first basis is people’s belief that ‘natural’ entities have superior advantages such as being more attractive, appealing, healthy and better for the environment. We refer to this as the ‘instrumental’ basis for the naturalness bias. These second basis is people’s belief that ‘natural’ entities are inherently better and ‘morally right’. We will refer to this as the ‘ideational’ basis for the naturalness bias (Rozin, 2004). Furthermore, we intend to explore whether or not the occurrence of a naturalness bias in lighting is affected by people’s beliefs towards lighting (Veitch & Gifford, 1996), or by their sense of personal connection with nature (Brügger et al., accepted for publishing). The first three studies of this paper are aimed at evaluating different methodologies, and at providing preliminary evidence whether the basis for the naturalness bias is more ideational or instrumental in the context of lighting. The fourth study aims to replicate the findings of the third study, as well as to provide further insights into why a naturalness bias could occur in the context of lighting.

**STUDY 1**

**RATIONALE**

This study was performed to explore the existence of a naturalness bias in the context of lighting. The naturalness bias has been described as a preference for things which are perceived as being ‘natural’. Rozin (2004) described that the naturalness bias has two bases: people perceive ‘natural’ entities as having superior advantages such as being more attractive, appealing, healthy and better for the environment (instrumental basis), and people perceive ‘natural’ entities as being inherently better and ‘morally right’ (ideational basis). In this study we attempt to find a valid way of eliciting the naturalness bias, while at the same time providing preliminary insights into whether the basis for the naturalness bias is more ideational or instrumental. The design of present study is aimed at isolating the ideational basis for the naturalness bias. In order to achieve this we compare people’s judgments of daylight to their judgments of artificial light which perfectly mimics the physical properties of daylight.
This isolates people’s ideas about how ‘moral’ or right those two kinds of lights are, as the light types are described to be physically identical. This results in the following hypothesis:

H1: People prefer rooms which are mostly illuminated by daylight over rooms which are mostly illuminated by artificial light perfectly mimicking the physical properties of daylight.

METHODS

Each participant was presented an A4 laminated paper with a printed photo of a cardboard model of a room, accompanied by a textual description of the room. Hidden in the description was a statement about the light in the room visualized in the picture. Different descriptions varied the proportions of daylight and artificial light claimed to illuminated the room. Figure 1 below visualizes the experiment.

A questionnaire consisting of four statements was presented along with each description to evaluate the ‘liking’ of the room visualized in the picture.
PARTICIPANTS

A total of 106 participants took part in the experiment, of which 54 (51.0%) were male, and 52 (49.0%) were female. Mean age was 20.5 years old, ranging between 17 and 28 years old. Most of the participants were undergraduate students. All participants were recruited at a Dutch college: Fontys HBO, Eindhoven. Subjects were reimbursed for participating with a lollipop.

PROCEDURE

Each participant was given an A4 laminated paper with a description and picture (model) of the room. After reading the description they were asked to fill out the questionnaire. The experiment took approximately five minutes to complete.

SETTING AND MATERIALS

A picture of a model (figure 2) was used in order to avoid any effects due to specific elements present in any picture of a real environment. The light sources in figure 2 are intended to represent light through a window and light from lighting fixtures. After viewing the picture and reading the description, participants completed a questionnaire, which tapped into their liking of the room visualized in the picture.

Figure 2: Picture of the model used in study 1

Each participant was presented with one out of two conditions, which are be visualized in figure 1 above. The only difference between the two conditions was the statement about the proportion of natural and artificial illumination in the room, which was hidden inside the description, either stating “20% of the light in the room is daylight and 80% of the light in the room comes from light fixtures designed to mimic natural light” or “80% of the light in the room is daylight and 20% of the light in the room comes from light fixtures designed to mimic natural light”.

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Below items and response scales were used, translated from Dutch into English:

1. How pleasant or unpleasant would you find it to work in this room for a day?  
   Five-point pleasant – unpleasant scale
2. How suitable or unsuitable do you find this room for being used as a working space?  
   Five-point suitable – unsuitable scale
3. How comfortable or uncomfortable would you find working in this room?  
   Five-point comfortable – uncomfortable scale
4. How good or bad do you find the atmosphere of this working space?  
   Five-point good – bad scale

MEASURES

The experiment consisted of one part, which was a rating task. Participants filled out a questionnaire consisting of four items (see above), on a five point Likert scale. These four items were averaged to obtain one measure for participants’ liking of the room visualized in the picture. The averaged liking measure had a Cronbach’s alpha of 0.84. Participants’ age and gender were also recorded.

RESULTS

Study 1 was conducted in order to explore the existence of a naturalness bias in the context of lighting. This study presented participants with a ambiguous picture (identical for the both conditions) of a model of a room, accompanied by a description giving meaning to the picture. The description incorporated a statement about the illumination in the room, which was varied between the two conditions. Participants’ liking of the room visualized in the picture was measured by a four-item questionnaire, which provided a single liking measure for each participant. Our hypothesis was that people would prefer rooms which were mostly illuminated by daylight over rooms which were mostly illuminated by artificial light perfectly mimicking the physical properties of daylight (H1).

Table 1 below shows the mean liking rating for each condition, sorted by the description used. As we can see in the table, condition 1, which describes the light to mainly come from artificial sources perfectly mimicking natural light, received nearly the same liking scores as condition 2, which described the light to mainly come from natural sources. Independent sample T-tests confirm that the difference in liking scores between the conditions is not significant (p=0.686).

Table 1: Mean ‘liking’ rating for each condition

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<table>
<thead>
<tr>
<th>Condition</th>
<th>Statement about the light in the room</th>
<th>Mean liking score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>“80% of the light in the room comes from light fixtures designed to mimic natural light”</td>
<td>3.32</td>
</tr>
<tr>
<td>2</td>
<td>“20% of the light in the room comes from light fixtures designed to mimic natural light”</td>
<td>3.24</td>
</tr>
</tbody>
</table>

Table 1: Mean liking scores for each version of the description

DISCUSSION

Study 1 was conducted in order to explore the existence of a naturalness bias in the context of lighting. It was specifically aimed at isolating the ideational basis for the naturalness bias, evaluating the hypothesis that people prefer rooms which are mostly illuminated by daylight over rooms which are mostly illuminated by artificial light perfectly mimicking the physical properties of daylight (H₁). Participants did not show a significant preference for either one of the rooms, disconfirming our hypothesis. It is possible that the non-significant result is due to the novelty value activated by rooms lit by a brand new type of lighting that perfectly mimics daylight. This idea is supported by a (non-significantly) higher mean liking score for the room mostly lit by the new type of lighting. Subsequent studies should use methodology which does not activate this value and which also taps into the instrumental basis for the naturalness bias.

STUDY 2

RATIONALE

Study 2 aims to repeat study 1, with changes made to methodology to address the concern that people’s preferences were affected by the novelty value of the type of lighting described in the experiment. It also aims to tap into both the instrumental and the ideational basis for the naturalness bias. This results in the following hypothesis:

H₁: People prefer rooms which are mostly illuminated by daylight over rooms which are mostly illuminated by artificial light.

METHODS

Please refer to the methods section of study 1 for methodology used. Figure 3 below visualizes the difference in methodology between study 1 and study 2.
PARTICIPANTS

A total of 56 participants took part in the experiment, of which 23 (41%) were male, and 33 (59%) were female. Mean age was 22.5 years old, ranging between 17 and 58 years old. Most of the participants were undergraduate students. All participants were recruited at a Dutch college: NHTV, Breda. Participants were reimbursed for participating with a lollipop.

PROCEDURE

Please refer to the procedure section of study 1.

SETTING AND MATERIALS

The picture used in this experiment is identical to the one used in study 1, see figure 2. In figure 3, the two conditions used are visualized. Each participant was presented with one of the conditions, exactly the same in their descriptions and lighting conditions, except for the statement about the artificial light.
1) 20% of the light in the room is daylight and 80% of the light in the room comes from the fixtures

2) 80% of the light in the room is daylight and 20% of the light in the room comes from the fixtures

The questionnaire included the same questions as in previous study.

MEASURES

The experiment consisted of one part, which was a rating task. The participants had to fill in a questionnaire consisting of four items (see setting and materials, study 1), on a five point Likert response scale. These four items were averaged to obtain one measure for participants’ liking of the room together with the description. The average liking measure of the first description had a Chrohnbach’s Alpha value of 0.86.

Additionally, subjects’ Age and Gender was recorded.

RESULTS STUDY 2

This study was conducted to evaluate whether there exists a Naturalness Bias in the context of lighting, considering both the Instrumental and the Ideational basis for the Naturalness bias. Our hypothesis was that the liking measure would be higher for the rooms, which were described to have mainly natural light as opposed to the rooms that were described to have mainly artificial lighting (H₁).

As we can see in table 2, condition 1, which described the light to mainly come from artificial sources, received nearly the same ‘liking’ scores as condition 2, which described the light to mainly come from natural sources. Independent sample T-tests confirm the difference in ‘liking’ scores between conditions one and two (p=0.974).

<table>
<thead>
<tr>
<th>Table 2: Mean ‘liking’ rating for each condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>
DISCUSSION

Study 2 was conducted in order to repeat study 1, addressing the concern that people’s preferences were affected by the novelty value of the type of lighting described in the experiment. It also aimed at tapping into both the instrumental and the ideational basis for the naturalness bias, resulting in the hypothesis that people prefer rooms, which are mostly illuminated by daylight over rooms which are mostly illuminated by artificial light (H1).

Results however showed that people liked both rooms equally well, meaning that the non-significant effect of study 1 was not only due to the concerns, which were addressed by the design of study 2. If a Naturalness Bias indeed does exist in the context of lighting, it is likely that the approach used in study 1 and 2 is not a suitable paradigm for eliciting it. It is possible that the paradigm is not suitable because the lighting manipulation was not direct enough. Furthermore, the pictures of the room model used in study 1 and 2 were aimed at preventing context effect introduced to participants basing their attitude on specific elements in the picture. However, there were informal indications that these pictures also introduced context effects of their own and were hard to combine with the description, possibly affecting participants’ attitudes.

STUDY 3

RATIONALE

Since the paradigm used in study 1 and 2 did not seem to be suitable for eliciting the naturalness bias in the context of lighting, we decided to try a different approach. The new approach makes use of a more direct manipulation, since the method used in study 1 and 2 seemed to have a manipulation that was not direct enough. Because the evaluation task used in the previous two studies appeared to be hard for participants, a forced choice task was implemented instead of an evaluation task. For the same reason, we decided to only use a visual cue (picture) in the new approach. Hence, the description used in study 1 and 2 seemed to be confusing to participants.

The aim of this study is identical to that of study 1 and 2: we aim to find a paradigm that is suitable for eliciting the naturalness bias in the context of lighting. This results in the following hypothesis:

H1: People prefer rooms, which are mostly illuminated by daylight over rooms which are mostly illuminated by artificial light.
METHODS

A set of two pictures was presented to participants. The pictures used were identical except for the fixtures of the artificial light in the room. In one picture the artificial lighting in the room was turned on, whereas in the other picture the artificial lighting in the room was manipulated and appeared to be turned off. Participants were asked which of the two presented rooms they preferred. In the manipulated picture where the lights seem to be turned off, the light in the rooms appears to originate from outside, giving the impression that the room is mostly illuminated by natural light.

PARTICIPANTS

Participants, mostly undergraduate students, were recruited from Radboud University Nijmegen. In total 105 subjects participated, 41 (39%) males and 64 (61%) females. Participants had a mean age of 22.2 years old, ranging between 18 and 30 years old.

Reimbursement for participation was a lollipop.

PROCEDURE

The participants were presented with a set of photos, in sequence, with a mask in between. Both photos were printed on A4 size paper and has been laminated. Each picture was shown for 10 seconds, with a grey masking sheet for 5 seconds in between. The order of presentation of the pictures was counterbalanced to control for order effects. The experiment took about 3 minutes to complete.

SETTING AND MATERIAL

The following set of photos was used in the visual choice task (figure 4). By changing the appearance of the fixtures participants either got the impression that the light in the room originates from the artificial lighting or from the windows. This approach is based on the idea that the manipulated pictures give the impression that the room is illuminated mostly by natural light. Thus, participants preferring the manipulated picture should prefer rooms which are mostly illuminated by natural light. In order to leave all other variables constant between the two conditions (e.g. amount of light in the picture, context such as furniture in the room) one of the photos was manipulated. Two pictures were taken from an identical viewpoint, one with the lights in the room turned on, and the other with the lights in the room turned off. The fixtures from the rooms with the lights turned off were pasted into the picture of the room with the lights turned on in order to create the ‘Lights off” condition.
MEASURES

Study 3 incorporated a visual choice task which presented participants with a set of two pictures. The two pictures were identical apart from that in one picture the artificial lighting in the room was turned on, and in the other picture the artificial lighting in the room was manipulated and seemed to be turned off. The pictures were manually presented in sequence, with a short distraction between the two pictures, after which participants were asked to indicate which of the two rooms they preferred. Our hypothesis was that people prefer rooms which are mostly illuminated by daylight over rooms which are mostly illuminated by artificial light (H1).

After being presented with the two pictures, participants were asked to indicate which room they preferred. This resulted in a single preference measurement for each participant.

Participants’ Age and Gender were also recorded.

RESULTS

Study 3 was conducted to test a different approach to eliciting the naturalness bias in the context of lighting. In this study, a visual choice task was used in order to evaluate whether this method was more suitable than the evaluation task used in study 1 and 2. The visual choice task presented participants with a set of two pictures, which were identical apart from the artificial lighting in the room. This lighting was turned on in the first picture, and was manipulated and seemed to be turned off in the other picture. The pictures were presented in sequence, with a short distraction between. Subsequently participants were asked to indicate which of the two rooms they preferred. Our hypothesis was that people would prefer rooms which were mostly illuminated by daylight over rooms which were mostly illuminated by artificial light (H1).
Of the 103 participants, 34 (33.0%) indicated they preferred the picture where the artificial lighting was turned on, and 69 (67.0%) indicated they preferred the picture where the artificial lighting was manipulated and seemed to be turned off, seemingly confirming $H_1$. A chi-squared test confirms that the difference in preferences is statistically significant: $\chi^2(1, 103) = 11.893, p<0.001$.

When we separated our data based on Gender, we found that of the 69 female participants, 16 (25.8%) indicated that they preferred the picture where the artificial lighting was turned on, and 46 (74.2%) indicated they preferred the picture where the artificial lighting was manipulated and seemed to be turned off. On the other hand, we found that of the 41 male participants, 18 (43.9%) indicated they preferred the picture where the artificial lighting was turned on, and 23 (56.1%) indicated they preferred the picture where the artificial lighting was manipulated and seemed to be turned off. It appears from these results that females had a larger preference for the picture where the artificial lighting was turned off. This was confirmed by two chi-squared tests, which verified that the females significantly preferred the picture with the lights turned off: $\chi^2(1, 69) = 14.52, p<0.001$, whereas males did not: $\chi^2(1, 41) = 0.61, p=0.435$.

**DISCUSSION**

Study 3 was conducted in order to try a different approach to eliciting the naturalness bias in the context of lighting. The visual choice task employed was used in an attempt to use a paradigm that did not have the same problems as the paradigm employed in study 1 and 2.

Results appear to support the existence of a naturalness bias in the context of lighting. Additionally, findings support the idea that the paradigm used in study 3 is suitable for eliciting the naturalness bias in the context of lighting. Further research is however needed in order to confirm that the used paradigm robustly measures the naturalness bias in the context of lighting across different picture sets. The finding that gender affects the occurrence of the naturalness bias indicates that it will be relevant to evaluate the effect of gender in subsequent studies.

One potential concern raised by the methodology of study 3 is the concern that the manual method of presenting the laminated pictures to participants could introduce a small amount of experimenter’s bias. It is possible that the experimenter, which was aware of the expected outcome of the study, provided the participants with nonverbal cues, slightly biasing their responses towards confirming our hypothesis. Subsequent studies using the visual choice task paradigm should present pictures in a more standardized and reliable manner.
STUDY 4

RATIONALE

Results of study 3 provided us with the first indication that a naturalness bias may exist in the context of lighting. The paradigm used in study 3 thus also seems to be a valid method for eliciting this bias.

Present study aims to replicate findings from study 3 and verify the effectiveness of the paradigm across different sets of pictures. This study also addresses concerns about experimenter’s bias introduced by the methodology of study 3, and uses a large sample of participants. Additionally, for this study we intended to look into the question why a naturalness bias could occur in the context of lighting. By looking at different measures we expect to have predictive value for its occurrence.

We expected that people who have a personal sense of connectedness to nature are more likely to prefer rooms illuminated mostly by natural light. Furthermore, we expected that people’s preferences for rooms with a certain type of light would be affected by their beliefs about natural and artificial light. People’s connectedness with nature is also likely to affect people’s beliefs about artificial and natural light, with a higher connectedness likely decreasing the amount of negative beliefs towards natural light, and increasing the amount of negative beliefs towards artificial light.

We reimbursed participants for participating in the study with a snack, offering the choice between a mandarin or a cookie with artificial flavoring. We intended to use people’s reimbursement choice as a measure, expecting that people who prefer a room, which is mostly illuminated by natural light, will also prefer a more natural snack.

Results of study 3 indicated that gender could have a significant influence of the strength of people’s preference for rooms which are most illuminated by natural light. Our final hypothesis is thus that gender significantly affects the strength of people’s preferences for rooms which are mostly illuminated by natural light. Below is an overview of the six hypotheses of study 4:

H1: People prefer rooms which are mostly illuminated by daylight over rooms which are mostly illuminated by artificial light.

H2: People who have a greater sense of personal connection to nature have an increased preference for rooms which are mostly illuminated by natural light.

H3: Negative beliefs about artificial lighting and positive beliefs about daylight increase the strength of people’s preference for rooms which are mostly illuminated by natural light.
$H_4$: People who have a greater sense of personal connection to nature will have less negative beliefs about daylight, and more negative beliefs about artificial light.

$H_5$: People who prefer a natural snack over a more artificial snack as reimbursement for participating in the study will be more likely to prefer rooms which are mostly illuminated by natural light.

$H_6$: People’s gender influences the strength of people’s preference for rooms which are mostly illuminated by natural light.

METHODS

Three sets of pictures were used, each set manipulated in the same way as the picture set used in study 3. A between-subject design was used, presenting each participant with one of the three sets of pictures. The main reason for using a between-subject design was the concern that participants could easily discover the manipulation that was employed when being presented with several sets of pictures, possibly introducing a confirmation bias. Computer software was used to present pictures to participants, in order to increase reliability and to address concerns of the manual presentation used in study 3, which introduced experimenter’s bias. After indicating their preference, participants received a paper questionnaire measuring their connectedness to nature and their beliefs towards different kinds of light.

PARTICIPANTS

A total of 314 participants were recruited over four days at Fontys HBO, Eindhoven. The majority of participants were young undergraduate students, of which 43.0% were females and 56.4% males. Mean age of participants was 22.3, ranging between 13 and 61 years old, with a standard deviation of 5.7 years.

PROCEDURE

The experiment started with a visual choice task. Pictures were presented using computer software to reliably manage time intervals for picture and mask presentation. The set of pictures used and the order of presentation were randomized to control for order effects. Participants were presented with each picture for 10 seconds, with a grey mask in between for 5 seconds. After viewing the pictures, participants had to make a forced choice of the two pictures they preferred. After indicating which room they preferred, participants completed a paper questionnaire. The experiment took about 10 minutes to complete.
SETTING AND MATERIALS

In order to complement the pictures used in study 3 (figure 5 below), two new sets of pictures were created using the same manipulation as the picture set adapted from study 3. The sets of pictures show different environments, including different combinations of light sources. This allows us to evaluate the robustness of the employed paradigm and the occurrence of the naturalness bias across different environments. As such, the environment depicted in set 2 (figure 6 below) is mostly illuminated by light bulbs, whereas the environment depicted in set 3 (figure 7 below) is mostly illuminated by fluorescent tubes.

Figure 5: The first picture set employed in study 4

Figure 6: The second picture set employed in study 4

Figure 7: The third picture set employed in study 4
The study was conducted in a classroom prepared with laptops, at Fontys Eindhoven, over duration of four days. Laptops were positioned in such way that it was impossible for participants to look at each other’s screen. Each laptop was prepared with software that timed the presentation of the pictures and mask, and which recorded people’s preference. A paper questionnaire was employed after participants completed the task on the laptop.

MEASURES

The experiment consisted of two parts; choice task on a laptop and a questionnaire on paper. Participants had to complete the choice task first prior to filling out the questionnaire.

Picture choice

The picture choice was made on the laptop. Participants were presented with two pictures in sequence; each picture was presented for 10 seconds, with a grey mask in between for 5 seconds. Participants’ choices were recorded as one dichotomous measure.

Questionnaire

After the picture choice, participants filled in a questionnaire. This questionnaire measured participants’ connectedness to nature, on a scale adapted from Brügger et al. (2009). The questionnaire also measured the amount of negative beliefs participants had towards light coming from fluorescent tubes, light bulbs and daylight, using items adapted from Veitch and Gifford (1996). Participant’s gender and age was also recorded.

Connectedness to nature

The first part of the questionnaire measures people’s connectedness to nature. The used scale was developed by Brügger et al. (2009). The scale was originally designed to be less cognitively demanding by measuring people’s connectedness to nature in an indirect way, using items which could be intuitively responded to without much cognitive effort. Using an indirect method of measuring connectedness to nature had the additional benefit that the individual response bias caused by cognitively demanding scales was avoided. Since only Dutch participants were recruited we translated the items of the questionnaire into Dutch.
The adapted questionnaire consisted of 40 statements. The first 17 items were statements which were responded to a 5-point Likert scale ranging from ‘Never’ to ‘Very Often’. The remaining 23 items were responded to a trichotomous scale with ‘Yes’, ‘No’ and ‘Does not Apply’. This resulted in 40 items providing information on the frequency with which participants engaged in 40 behaviors related to being connected with nature. The RASCH model was used to obtain an ordering of these 40 items ordered by the ‘cost’ of engaging in each behavior. This ordering was subsequently used to obtain a score for connectedness to nature for each participant. Fit statistics show that only two of 40 items used to compute the connectedness to nature scale show significant misfit with the model, which is within tolerances. The RASCH model returned an Item Reliability of 0.99, a Person Reliability of 0.86, and a Cronbach’s alpha of 0.87 for the resulting measure, confirming that the connectedness to nature items reliably produce one measure for each participant, without significant misfit of items in the model.

The second part of the questionnaire was developed to measure beliefs towards light originating from fluorescent tubes, light bulbs and daylight. Eighteen items were used in total, six for each type of light. Table 3 below shows the six items that were used. The second statement was excluded from the measures because of validity concerns. This concern was mostly caused by the statement being interpreted ambiguously, sometimes being perceived as a positive statement, and sometimes as a negative statement. The remaining five items for each light type were combined into a single measure of negative beliefs towards each type of light. The three negative belief measures had Chronbach’s Alpha values of 0.63, 0.46, and 0.54 respectively for light originating from fluorescent tubes, light bulbs and daylight. This indicates that there are some concerns about the negative belief measures measuring a single construct. Subsequent studies should adapt the used items in order to increase the quality of these measures.

<table>
<thead>
<tr>
<th>Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Light source] light gives me a headaches</td>
</tr>
<tr>
<td>[Light source] lighting does not affect one's health <strong>EXCLUDED</strong></td>
</tr>
<tr>
<td>[Light source] light spreads a smooth, pleasant light over working spaces</td>
</tr>
<tr>
<td>[Light source] lighting makes your skin look an unnatural or strange color</td>
</tr>
<tr>
<td>[Light source] lighting makes people tired</td>
</tr>
<tr>
<td>[Light source] lighting is stimulating, it makes me feel energetic</td>
</tr>
</tbody>
</table>
Reimbursement

After completing the experiment participants could choose either a mandarin fruit or a cookie with artificial flavoring as reimbursement. Participants’ choice of reimbursement was recorded, and used as an independent measure, following the rationale that participants who choose a natural reimbursement (fruit) over a less natural reimbursement (a cookie with artificial flavoring) would be more likely to also prefer rooms which are mostly illuminated by natural light.

RESULTS

Study 4 has methodology based on the visual choice task approach of study 3. Participants were presented with a set of two pictures, which were identical apart from that in one picture the artificial lighting in the room was turned on, and in the other picture the artificial lighting in the room was manipulated and seemed to be turned off. Participants were then asked to indicate which one of the two rooms they preferred. We hypothesised that people would prefer rooms which are mostly illuminated by daylight over rooms which are mostly illuminated by artificial light (H1). We further made three hypotheses about why the naturalness bias could occur in the context of lighting. Firstly, we hypothesized that people who had a greater sense of personal connection to nature would have an increased preference for rooms which are mostly illuminated by natural light (H2). Secondly, we hypothesized that negative beliefs about artificial lighting and positive beliefs about daylight would increase the strength of people’s preference for rooms which are mostly illuminated by natural light (H3). Thirdly, we hypothesized that people who preferred a natural snack over a more artificial snack as reimbursement for participating in the study would be more likely to prefer rooms which are mostly illuminated by natural light (H5). Additionally, we hypothesized that people who had a greater sense of personal connection to nature would have less negative beliefs about daylight, and more negative beliefs about artificial light (H4). Finally, we hypothesized that the strength of people’s preference for rooms which are mostly illuminated by natural light would be significantly influenced by their gender (H6).

Table 4 below summarizes the participants’ preferences grouped by the picture set used. As can be seen from the table, participants overall preferred the picture with the lights turned off for picture sets 1 and 3. Chi-squared tests indicate that this preference is statistically significant for picture set 3: \( \chi^2(1, 105) = 6.50, p=0.011 \); yet not statistically significant for picture set 1: \( \chi^2(1, 105) = 2.14, p=0.143 \).

Table 4 also shows that participants had an overall preference picture with the lights turned on for picture set 2, which indicates this set has a preference effect in the opposite direction of the effect
found for picture sets 1 and 3. A chi-squared test confirms that there is a statistically significant preference for the picture with the lights turned on for picture set 2: $\chi^2(1,105) = 4.20, p=0.040$.

Table 4: Number of people preferring condition with the lights on/off

<table>
<thead>
<tr>
<th>Picture set 1</th>
<th>Chosen: lights on condition</th>
<th>Chosen: lights off condition</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45 (42.9%)</td>
<td>60 (57.1%)</td>
<td>105 (100%)</td>
</tr>
<tr>
<td>Picture set 2</td>
<td>63 (60.0%)</td>
<td>42 (40.0%)</td>
<td>105 (100%)</td>
</tr>
<tr>
<td>Picture set 3</td>
<td>39 (37.5%)</td>
<td>65 (62.5%)</td>
<td>104 (100%)</td>
</tr>
</tbody>
</table>

In order to evaluate whether people who had a greater sense of personal connection to nature had an increased preference for rooms mostly illuminated by natural light ($H_2$), we used a binary logistic regression attempting to predict people’s room preference from their connectedness to nature. The resulting model indicated that connectedness to nature did not significantly predict picture preference ($p=0.517$ overall, $p=0.467$, $p=0.835$, and $p=0.561$ for picture sets 1, 2, and 3 respectively).

Table 5 below summarizes the mean values participants scored on negative beliefs about light originating from light bulbs, fluorescent tubes, and daylight. It reports the amount of negative beliefs toward each type of light, thus higher values indicate more negative beliefs. As can be seen from the table, people had most negative beliefs about light originating from fluorescent tubes, least negative beliefs about daylight, with the amount of negative beliefs towards light originating from light bulbs in between.

Table 5: Negative beliefs towards different light types

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean Score</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative Beliefs towards light coming from the Sun</td>
<td>0.95</td>
<td>0.6</td>
</tr>
<tr>
<td>Negative Beliefs towards light coming from Light Bulbs</td>
<td>1.82</td>
<td>0.75</td>
</tr>
<tr>
<td>Negative Beliefs towards light coming from Fluorescent Tubes</td>
<td>2.42</td>
<td>0.67</td>
</tr>
</tbody>
</table>

In order to evaluate whether negative beliefs about artificial lighting and positive beliefs about daylight increased the strength of people’s preference for rooms mostly illuminated by natural light ($H_3$), four binary logistic regressions were used. One for the overall dataset and one for each individual picture set. Results indicate that negative beliefs towards daylight did not affect peoples’ room preference ($p=0.724$ overall, $p=0.394$, $p=0.682$, and $p=0.642$ for picture sets 1, 2, and 3 respectively). Also, negative beliefs towards light originating from light bulbs did not affect people’s room preference.
(p=0.399 overall, p=0.141, p=0.320, and p=0.503 for picture sets 1, 2, and 3 respectively). Finally, negative beliefs towards light coming from fluorescent tubes did also not affect people’s room preference (p=0.841 overall, p=0.463, p=0.277, and p=0.666 for picture sets 1, 2, and 3 respectively).

In order to evaluate our hypothesis that people who had a greater sense of personal connection to nature would have less negative beliefs about daylight, and more negative beliefs about artificial light (H₄), we computed the correlations between participants’ connectedness to nature and our three measures for negative beliefs about fluorescent tubes, light bulbs, and daylight. Results indicate that connectedness to nature has a Pearson correlation of 0.259 (p<0.001) with negative beliefs about fluorescent tubes, a Pearson correlation of 0.223 (p<0.001) with negative beliefs about light bulbs, and a Person correlation of -0.190 (p=0.001) with negative beliefs about daylight.

In order to evaluate whether people who preferred a natural snack over a more artificial snack as reimbursement for participating in the study, would be more likely to prefer rooms which are mostly illuminated by natural light (H₅), we look at data gathered on people’s reimbursement choice. Of the 314 participants, 56 (17.8%) chose a mandarin, 106 (32.2%) chose a cookie with artificial flavoring, and 157 (50.0%) chose not to take any reimbursement. Table 6 summarizes people’s picture preferences, connectedness to nature, and beliefs towards light separated by their choice of incentive.

Table 6: Participant’s picture choice, connectedness to nature and beliefs towards light separated by choice of incentive

<table>
<thead>
<tr>
<th></th>
<th>Participant chose mandarin</th>
<th>Participant chose cookie</th>
<th>Participant chose to get no reimbursement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage preferring picture with the lights off for picture set 1</td>
<td>47%</td>
<td>52%</td>
<td>64%</td>
</tr>
<tr>
<td>Percentage preferring picture the with lights off for picture set 2</td>
<td>45%</td>
<td>41%</td>
<td>37%</td>
</tr>
<tr>
<td>Percentage preferring picture the with lights off for picture set 3</td>
<td>73%</td>
<td>62%</td>
<td>60%</td>
</tr>
<tr>
<td>Connectedness to Nature</td>
<td>-0.61</td>
<td>-0.90</td>
<td>-0.95</td>
</tr>
<tr>
<td>Negative Beliefs towards light originating from fluorescent tubes</td>
<td>2.52</td>
<td>2.49</td>
<td>2.34</td>
</tr>
<tr>
<td>Negative Beliefs towards light originating from light bulbs</td>
<td>1.80</td>
<td>1.88</td>
<td>1.80</td>
</tr>
<tr>
<td>Negative Beliefs towards daylight</td>
<td>0.80</td>
<td>0.97</td>
<td>1.00</td>
</tr>
</tbody>
</table>
The first thing we see in table 6 is that picture choices of participants that chose a mandarin seem to be slightly different from the picture choices of participants that picked a cookie or no incentive. Independent sample t-tests however indicate that participant’s choice of incentive have no significant influence on their picture preferences (p=0.949 overall, p=0.346, p=0.354, and p=0.561 for picture sets 1, 2, and 3 respectively). Interesting is however, that table 6 also shows that participants who picked a mandarin as incentive seem to have less negative beliefs towards daylight and a higher connectedness to nature than participants that picked a cookie or no incentive. Independent sample t-tests confirm that participants that picked a mandarin had less negative beliefs towards daylight than people that picked a cookie (p=0.047 one-sided) and people that picked no incentive (p=0.020 one-sided), as well as a higher connectedness to nature than participants that picked a cookie (p=0.055 one-sided) and participants that picked no incentive (p=0.026 one-sided).

Since results from study 3 indicate that gender may affect the occurrence of a naturalness bias in the context of lighting, we finally evaluate whether or not people’s gender influences the strength of their preferences (H6). For picture set 1 we found that 54% of the male participants and 60% of the female participants preferred the picture where the artificial lighting seemed to be turned off. For picture set 2, 44% of the male participants and 35% of the female participants preferred the picture where the artificial lighting seemed to be turned off. For picture set 3, 64% of the male participants and 60% of the female participants preferred the picture where the artificial lighting seemed to be turned off. Judging from these results, it seems that gender does not affect the strength of people’s preferences. Independent sample t-tests indeed confirm that gender does not significantly affect the strength of people’s preferences (p=0.585 two-sided overall, p=0.590, p=0.384, and p=0.649 two-sided for picture sets 1, 2, and 3 respectively).

DISCUSSION

Study 4 aimed to replicate findings from study 3 in order to provide further evidence for the existence of a naturalness bias in the context of lighting, and verify the effectiveness of the paradigm used in study 3 across different sets of pictures. Changes made while adapting the methodology from study 3 address concerns about experimenter’s bias raised by the methodology of study 3. Study 4 additionally looked into the question why a naturalness bias could occur in the context of lighting by looking at different measures expected to have predictive value for its occurrence. Finally, study 4 attempted to replicate the effect of gender on people’s preferences as found in study 3.
We hypothesised that people would prefer rooms, which are mostly illuminated by daylight over rooms which are mostly illuminated by artificial light (H₁). We further made three hypotheses about why the naturalness bias could occur in the context of lighting. Firstly, we hypothesized that people who had a greater sense of personal connection to nature would have an increased preference for rooms which are mostly illuminated by natural light (H₂). Secondly, we hypothesized that negative beliefs about artificial lighting and positive beliefs about daylight would increase the strength of people’s preference for rooms which are mostly illuminated by natural light (H₃). Thirdly, we hypothesized that people who preferred a natural snack over a more artificial snack as reimbursement for participating in the study would be more likely to prefer rooms which are mostly illuminated by natural light (H₅). Additionally, we hypothesized that people who had a greater sense of personal connection to nature would have less negative beliefs about daylight, and more negative beliefs about artificial light (H₄). We also hypothesized that people who prefer a natural snack over a more artificial snack as reimbursement for participating in the study will be more likely to prefer rooms which are mostly illuminated by natural light (H₅). Finally, we hypothesized that the strength of people’s preference for rooms which are mostly illuminated by natural light would be significantly influenced by their gender (H₆).

Results only provided support for a naturalness bias for picture set 3. Interestingly, we failed to replicate a significant preference for picture set 1, while this picture set was identical to the picture set used in study 3. Even more interestingly, a significant reversed preference was found for picture set 2. These findings support the idea that the visual choice paradigm needs to be refined in order to reliably elicit a naturalness bias in the context of lighting, and possibly is unsuitable for eliciting the naturalness bias in the context of lighting.

Results further disconfirm H₂, H₃, H₅, showing that people’s preference for rooms which are mostly illuminated by natural light is not affected by their beliefs towards daylight and artificial light, nor by their connectedness to nature or whether they chose a more natural reimbursement for participating in the study. We however did find a correlation between people’s connectedness to nature and their beliefs towards different light sources, confirming H₄. Furthermore, participants’ reimbursement choice significantly correlated with people’s connectedness with nature; participants which chose a natural reimbursement (a mandarin instead of a cookie with artificial flavoring) had a significantly higher connectedness to nature. Also, participant’s choice of incentive significantly correlated with their amount of negative beliefs towards daylight; participants which chose a more natural reimbursement had less negative beliefs about daylight. These findings provide us with a strong indication that even though the paradigm employed in study 4 doesn’t seem to reliably elicit the
naturalness bias, the measures used for connectedness to nature, beliefs towards light and reimbursement are reliable. The finding that these measures correlate with each other in directions consistent with their meaning provides the measures with some degree of convergent validity, as they all seem to be measuring similar constructs. Reliability statistics of our measures for beliefs towards light also indicate that improvements can be made to the specific items used in the belief measures.

When evaluating the effect of gender on the strength of people’s preferences in study 4, we found that gender did not have a significant effect for any of the three picture sets used, disconfirming H6. Since study 4 used three different picture sets, one of which was identical to that of study 3, we have strong reason to believe that the effect of gender found in study 3 does not apply to the general population.

In summary, the large difference in measured preference effects between the different picture sets gave us strong indication that the visual choice task paradigm employed in study 4 did not reliably measure a naturalness bias in the context of lighting. This idea is strongly supported by the finding that our predictive measures, which appear to be reliable and valid, do not correlate with people’s picture preference. Further research is needed in order to explore and improve methodologies if we are to find a paradigm that reliably elicits the naturalness bias in the context of lighting. The predictive measures used in this study provide a good basis for evaluating whether a paradigm elicits the naturalness bias, as these measures are highly likely to correlate with a valid measure for naturalness bias in the context of lighting.

**FINAL DISCUSSION AND FUTURE RESEARCH**

Study 1, 2 and 3 were aimed at exploring the effectiveness of different approaches to eliciting the naturalness bias in the context of lighting. Study 1 and 2 implemented evaluation tasks where participants had to form an attitude towards an ambiguous picture accompanied by a description. The first experiment aimed specifically at isolating the ideational basis for the naturalness bias. Since study 1 did not return significant results we decided to conduct study 2, which looked at both the ideational and instrumental bases for the naturalness bias. The results from study 2 were also not significant, indicating that the ‘evaluation task’ paradigm used in study 1 and 2 seems not to be suitable for tapping into the naturalness bias in the context of lighting. It is possible that the paradigm is not suitable because the lighting manipulation was not direct enough. Furthermore, the picture used in study 1 and 2 may have introduced context effects of its own, even though we explicitly opted to use a picture of a model in order to avoid introducing context effects.
Study 3 implemented a visual choice task. Participants were shown two pictures of a room which were identical except for the fixtures of the artificial lighting in the room, which were turned on in one picture, and were manipulated in the other picture and seemed to be turned off. Participants were asked which of the two rooms they preferred, following the rationale that in the picture where the artificial lighting seemed to be turned off, the room gave off the impression of being illuminated mostly by natural light. Findings indeed showed an overall preference for the room that appeared to be mostly illuminated by natural light. This supported the idea that the ‘visual choice task’ paradigm is suitable for eliciting a naturalness bias in the context of lighting.

Study 4 was conducted in order to verify the effectiveness of the visual choice task paradigm across different sets of pictures, using a more reliable research setup and a greater number of participants. Additionally, study 4 looked at the question why a naturalness bias could occur in the context of lighting by looking at different measures expected to have predictive value for its occurrence.

Results from study 4 showed that a naturalness bias seemed to be present only in one of the three picture sets employed. Additionally, one of the three picture sets showed a significant preference effect in the direction opposite to the one that was hypothesized. This provides us with a strong clue that the visual choice task paradigm to be refined, and could be unsuitable for eliciting a naturalness bias in the context of lighting.

Interestingly, study 4 also showed that people’s connectedness to nature significantly correlated with their beliefs towards different light sources; people who were more connected to nature had less negative beliefs towards daylight, and more negative beliefs towards light originating from fluorescent tubes and light bulbs. Additionally, people’s reimbursement choice significantly correlated with their connectedness to nature and beliefs towards daylight; people who chose a more natural reimbursement (mandarin) scored higher on the connectedness to nature scale and had less negative beliefs towards daylight than the people that chose a less natural reimbursement (cookie with artificial flavoring, or no incentive). The finding that these measures correlate with each other in directions consistent with their meaning provides them with some degree of convergent validity, as they all seem to be measuring similar constructs. The finding that these measures, which appear to be reliable and valid, do not correlate with people’s picture preference provides strong support that the visual choice task paradigm employed in study 4 need to be refined, and could be unsuitable for eliciting a naturalness bias in the context of lighting.
The main conclusion of this paper is that further research is needed if we want to find a paradigm that reliably measures a naturalness bias in the context of lighting. The most important criterion should be that the naturalness bias measure correlates with measures that should correlated with it, such as people’s connectedness to nature and beliefs towards different kinds of light. Future research should focus on testing different methodologies of eliciting a naturalness bias in the context of lighting, possibly improving our ‘visual choice task’ paradigm, or trying approaches different from the ones evaluated in our four studies.
REFERENCES


